The Effect of Low Level Laser Therapy on Pressure Pain Threshold in Patients with Temporomandibular Disorders : A Double-blind Study

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CONTENTS

I. INTRODUCTION

Temporomandibular disorders is increasingly being viewed as a syndrome in which a constellation of disturbances relating to the temporomandibular joints and associated musculatures interacts, leading to clinical signs and symptoms[1]. Treatment methods of temporomandibular disorders include pharmacologic therapy, splint therapy, occlusal adjustment and physical therapy, etc. Physical therapy commonly employed in the treatment of temporomandibular disorders includes thermotherapy, coolant application, ultrasound therapy, transcutaneous electrical nerve stimulation, acupuncture and laser therapy[2].

During the last 10-15 years, low level laser has commercially available for routine clinical use[3]. Two principally different main areas have been proposed as being suitable for laser treatment : inflammatory diseases or ulcers[4-6] and pain conditions of any kind[3,7]. Typical low level lasers today are the 633nm red He-Ne gas laser and the infrared(IR) 803nm Ga-Al-AS and 904 nm Ga-As diode lasers[3].

Low level laser therapy(LLLT) has been applied to many musculoskeletal pain syndromes in clinical trials since Mester et al reported on the biological and medical effect of LLLT in the early seventies[8]. The effect of LLLT had been researched on CMD by Bezuur et al[9] in 1988, chronic orofacial pain by Hansen and Thoroe[10] in 1990, chronic low back pain by Klein and Eek[11] in 1990, trigger point by Olavie et al[12] and Snyder-Mackler et al[13] in 1989, chronic myofascial pain by Waylonis et al[14] in 1988 and by Thorsen et al[15] in 1991. However, many researchers and practitioners have questioned the biological and clinical benefits of LLLT.

More recently double-blind controlled studies

have failed to show any difference between actual and placebo laser treatment in chronic orofacial pain[10], chronic low back pain[11] and chronic myofascial pain[15]. Although Ceccherelli et al[16] reported positively in cervical myofascial pain, Berckerman et al[17] proposed that there were some problems not taking properly into account the results of the control group in the study.

There are many clinical methods to evaluate the effect of treatment. Some researches[18-20] used palpation index to evaluate the treatment effect in TMD patient. Because the examiner's fingers are used in palpation and so there can be a bias between examiner and subjects, it is difficult to formulate, evaluate and analyze it objectively. Other investigators have used visual analogue scale(VAS)[21] to evaluate the effect of many kinds of physical therapy[22] and pharmacologic therapy[23]. As measurement of VAS depends on the subjectivity of individual perception, it is less objective to use VAS. As pressure algometer enables the quantification of local muscle tenderness in patients with musculoskeletal disorders and asymptomatic subjects[24-26], it is more objective to measure pressure pain threshold(PPT)[27,28]. This has used in evaluating hypersensitive spots[29], fibrositis[27] and activity of arthritis[30], and documenting clinical effects of different treatment such as intramuscular injection[31], physical therapy[32], transcutaneous electrical nerve stimulation (TENS)[33], laser therapy[12] and acupuncture and occlusal splint[34]. Thus, it is seemed that a research to assess the effect of LLLT by means of pressure pain threshold is needed.

The purposes of this study were to evaluate the effect of GaAlAs diode laser therapy using algometer in TMJ, the head and neck muscles of TMD patients and normal subjects after laser irradiation, which might alter the pain intensity clinically and subjectively in a double-blind study, to compare actual laser-induced effect with placebo, and to investigate the time that shows beneficial effect of LLLT on each muscle of TMD patients.

II. MATERIALS AND METHODS

Subjects

81 dental students at Pusan National University were investigated TMD symptoms with a self-administered Solberg Questionnaire[35], interview and clinical examination. As 33 who had vague symptoms or previous history of TMD therapy were exclude, 24 with TMD symptoms were selected for patient group and 24 without TMD symptoms for control group at the beginning of this study. Each patients and control subjects were evenly randomly assigned to LLLT and sham LLLT group. Thus, this study included 4 groups : patients group receiving the LLLT, patients group receiving the sham LLLT, control group receiving the LLLT and control group receiving the sham LLLT. 9 dropped out because they were not able to fill out the scheme regularly and satisfactorily. 10 in LLLT-patient group, 9 in sham LLLT-patient group, 10 in LLLT-control group and 10 in sham LLLT-control group took part completely in this scheme.

Apparatus

The electronic algometer type I(Somedic production, Stockholm, Sweden)[36] used in this study consists of a gun shaped application handle with a round rubber tip, a main body that has a digital display panel , calibration knob and control knob of application rate slope, and a patient-operated switch(Fig.1). The PPT was measured in Kpa by algometer. The algometer

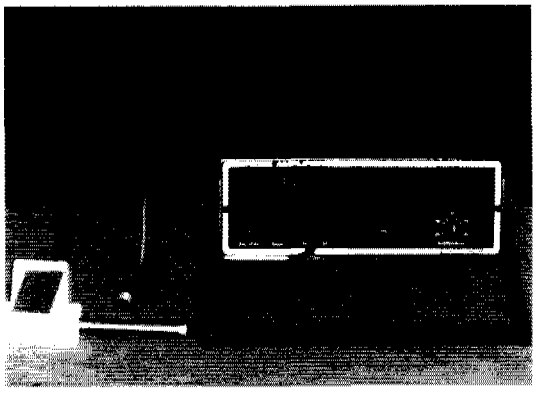

Fig. 1. The components of the electronic algometer.

handle was applied perpendicularly to all the muscles and the application speed was maintained at 30 Kpa/sec.

The laser apparatus used in this study was a handylaser 50-SL® [37] which was a 820nm, 50mW, GaAlAs diode laser. The power output can be regulated with ease and precision; The laser was set to be on for 40 seconds and to be automatically turned off. Laser was set to deliver a pulse energy at 1J/cm^2 for 40 seconds. This laser apparatus is ideally designed for a double blind study since the laser light is invisible and emits neither heat, sound nor other physically detectable indication when it is activated.

Procedure

The subjects were examined respectively by an examiner. Each patient was assessed on the following findings ; 1) pain intensity as a subjective symptom[38], 2) craniomandibular index(CMI)[18-20], and pressure pain threshold (PPT)[22,23] on 32 musculoskeletal palpation points as indicated by Fricton[19,20] as clinical findings at pre-treatment, the second week and the fourth week of laser or sham laser irradiation. Pain intensity was evaluated with numerical analogue scale(NAS). The patients were asked to rate their pain using a numerical scale of 0 to 10. The 0 on the scale was estimated to be "no pain" and 10 to be "pain as bad as can be"[38].

Laser was irradiated on the following 32 musculoskeletal points[19,20]. PPT and PI measurements were carried out on the same points to evaluate the effect of LLLT. They were found in extraoral, neck and TMJ palpation in CMI[19,20] and were able to be approached by algometer(Fig.2)

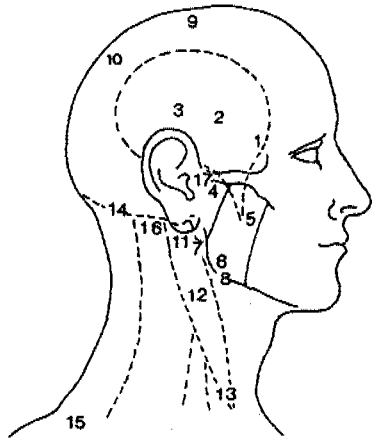

Fig. 2. 32 musculoskeletal palpation points of head and neck
1) Anterior Temporalis
2) Deep Temporalis
3) Middle Temporalis
4) Deep Masseter
5) Anterior Masseter
6) Inferior Masseter
7) Posterior Digastric
8) Medial Pterygoid
9) Vertex
10) Reference Point[19,20]
11) Superior Sternocleidomastoid
12) Middle Sternocleidomastoid
13) Inferior Sternocleidomastoid
14) Trapezius Insertion
15) Upper Trapezius
16) Splenius Capitis
17) Lateral Capsule

LLLT

All of subjects received either LLLT or sham LLLT according to the scheme. Each point was irradiated with either 2J/cm^2 of pulsed or sham laser for 80 seconds. Each subject was treated twice during the first week, once a week during the following three weeks and so has received total 5 sessions. The probe was in contact with skin at a right angle. The same unit was used for sham irradiation, at which no laser beam was emitted(Fig.3).

PPT

Before examination, subjects were instructed to push button on patient-operated switch as soon as they recognized pain. As subject feels pain, he or she pushes button on patient-operated switch, digital display stops immediately for about five seconds, and red light turns on so operator can record the value easily. During this test, he or she who made measurement did not see the values of measurement.

The tests on masticatory and anterior neck muscles and temporomandibular joints were performed on subjects in a supine position with neck supported. During the measurement on masticatory muscles and temporomandibular joints, examiner applied manual counter-pressure contralaterally to stabilize head(Fig.4).

The tests on posterior neck muscles and vertex were performed on subjects in sitting position. During the measurement on posterior neck muscles except upper trapezius muscle, examiner applied manual counter-pressure frontally(Fig.5).

For reliability the measurements were taken

Fig. 4. The electronic algometer applied to the anterior masseter of patient in supine position.

Fig. 3. The low level laser applied to the anterior masseter

Fig. 5. The electronic algometer applied to the upper trapezius in sitting position

three times at each point and the mean value of the three measurements was accepted. The PPT was taken at pre-treatment, the second and the fourth week of irradiation. The PPT measurements on the second and the fourth week of irradiation were made between the third day and the seventh day after irradiation.

Craniomandibular Index(CMI)

CMI was divided into items which reflect TMJ tenderness and functioning, termed dysfunction index(DI), and items which reflect muscle tenderness problems, termed palpation index(PI). DI includes items related to limits in range of motion, deviation in movements, pain during movement, TMJ noise during movement, and TMJ tenderness.

PI includes items related to tenderness at distinct anatomical sites during intraoral jaw muscles palpation, and extra-oral palpation of jaw and neck muscles. Scoring of CMI was designed to give equal weight and 0 to 1 scores to DI and PI. To do this, DI was calculated by using sum of positive responses related to mandibular movements, TMJ noise, TMJ palpation divided by total number of items<26>. PI was calculated by using sum of positive responses related to palpation of jaw and neck muscles and TMJ capsule divided by total number of items<36>. CMI is sum of DI and PI divided by 2.

To preserve double-blind study, subjects were allowed not to view laser beam and PPT value, while he or she was irradiated with LLLT or sham LLLT and was examined with algometer. Two therapists were not aware of whether the subject was patient or normal, and results of measurements.

Statistical Analysis

PPT, CMI and pain intensity in TMJ, head and neck muscles at pre-treatment, the second week and the fourth week of irradiation in all groups were compared by paired t-test using the Statview ^{TM} II to evaluate the effect of LLLT in TMJ, head and neck muscles of TMD patients and normal subjects.

PPT values between patient and control group before treatment were compared to confirm the experiment. To assess the difference between actual laser-induced effect and placebo, the increased PPT differences in LLLT-patient and sham LLLT-patient group according to treatment were compared. The treatment period which exhibited significantly increased PPT values in each muscle according to treatment in LLLT-patient and sham LLLT-patient group was compared to investigate when LLLT showed beneficial effect on each muscle of TMD patient. Statistical analysis of PPT values between patient and control group before treatment, increased PPT differences in LLLT-patient and sham LLLT-patient group by treatment, and the effective treatment period in PPT of each muscle by treatment in LLLT-patient and sham LLLT-patient group were performed with repeated measures ANOVA in the Statview ^{TM} II.

Ⅲ. RESULTS

The PPT values of the patient and the control groups at pre-treatment are shown in table 1 and figure 6. The PPT values of all patient group were significantly lower than those of all control group, at pre-treatment in all muscles($p<0.05$).

Table 2 and figure 7 shows the PPT values of the LLLT-patient group at pre-treatment, the second and the fourth week of laser irradiation.

Table 1. Pressure pain threshold of the patient group and the control group at pre-treatment(Kpa)

	patient group	control group	p-value
anterior temporalis(AT)	161.53 ± 29.82	253.80 ± 56.72	<0.0001
deep temporalis(DT)	195.49 ± 40.08	296.56 ± 68.86	<0.0001
middle temporalis(MT)	211.87 ± 48.12	306.26 ± 60.76	<0.0001
deep masseter(DM)	152.00 ± 33.62	245.21 ± 52.65	<0.0001
anterior masseter(AM)	166.17 ± 32.90	234.94 ± 51.33	<0.0001
inferior masster(IM)	143.12 ± 28.04	229.84 ± 55.94	<0.0001
posterior digastric(PD)	121.28 ± 24.93	193.25 ± 39.80	<0.0001
medial pterygoid(MP)	155.97 ± 33.68	226.62 ± 58.12	<0.0001
vertex(V)	221.54 ± 75.87	318.38 ± 98.77	0.0011
reference point(RP)	248.78 ± 87.11	359.07 ± 91.02	0.0002
superior SCM*(SS)	172.13 ± 38.44	245.13 ± 58.59	<0.0001
middle SCM*(MS)	113.58 ± 28.16	165.67 ± 46.74	<0.0001
inferior SCM*(IS)	157.91 ± 40.13	216.38 ± 51.10	<0.0001
trapezius insertion(TI)	177.41 ± 34.59	271.09 ± 76.15	<0.0001
splenius capitis(SC)	182.55 ± 41.76	269.96 ± 57.17	<0.0001
upper trapezius(UT)	163.60 ± 33.37	242.29 ± 67.04	<0.0001
lateral capsule(LC)	156.73 ± 33.30	237.97 ± 55.87	<0.0001

* ; sternocleidomastoid muscle

The PPT values were significantly increased in the most muscles of this group by the laser irradiation($p<0.05$). However, there were no differences between PPT values of pre-treament and those of the fourth week in the vertex, reference point, superior sternocleidomastoid and splenius capitis.

The PPT values of the sham LLLT-patient group at pre-treatment, the second and the fourth week of sham laser irradiation are seen in table 3 and figure 8. The PPT values in most muscles of this group were significantly increased by the sham laser irradiation ($p<0.05$), but the PPT values between pre-treatment and the fourth week were not different in posterior digastric, vertex, reference point, middle sternocleidomastoid, trapezius insertion, upper trapezius and splenius capitis.

The PPT values at pre-treatment, the second and the fourth week of laser irradiation in the LLLT-control group and the sham LLLT-control group are shown in table 4, 5 and figure 8, 9. The PPT values in both group were not increased after each actual laser or sham laser irradiation.

Table 6 and figure 11 summarizes the pressure pain threshold differences of the LLLT-patient and the sham LLLT-patient group according to

Table 2. Pressure pain threshold of the LLLT-patient group at pre-treatment, the second week and the fourth week of laser irradiation(Kpa)

	pre-treatment	second week	fourth week	p-value
anterior temporalis(AT)	165.70 ± 26.60	205.34 ± 43.88	213.97 ± 41.01	a,c
deep temporalis(DT)	197.95 ± 38.74	240.87 ± 53.54	258.84 ± 56.67	a,b,c
middle temporalis(MT)	219.11 ± 51.12	244.53 ± 60.89	260.31 ± 70.60	a,c
deep masseter(DM)	165.12 ± 34.66	176.40 ± 46.97	185.20 ± 50.01	c
anterior masseter(AM)	176.97 ± 31.76	198.41 ± 49.46	211.01 ± 47.32	a,c
inferior masster(IM)	150.00 ± 31.59	185.60 ± 70.86	188.61 ± 47.84	a,c
posterior digastric(PD)	128.95 ± 25.93	145.08 ± 40.86	156.15 ± 35.95	a,b,c
medial pterygoid(MP)	169.81 ± 33.21	183.10 ± 41.50	206.28 ± 47.78	a,b,c
vertex(V)	252.86 ± 80.89	280.74 ± 97.18	296.34 ± 88.29	
reference point(RP)	293.71 ± 89.90	311.11 ± 73.01	312.98 ± 86.77	
superior SCM*(SS)	187.08 ± 40.92	197.05 ± 49.94	206.08 ± 52.27	
middle SCM*(MS)	125.34 ± 30.05	136.92 ± 45.14	144.24 ± 54.73	c
inferior SCM*(IS)	173.47 ± 38.25	188.25 ± 35.14	198.01 ± 49.14	c
trapezius insertion(TI)	183.32 ± 40.20	187.40 ± 45.75	218.44 ± 53.14	b,c
splenius capitis(SC)	192.76 ± 45.80	209.75 ± 43.67	203.50 ± 46.62	a
upper trapezius(UT)	170.19 ± 39.04	177.39 ± 50.25	197.54 ± 65.91	b,c
lateral capsule(LC)	162.58 ± 37.20	184.47 ± 41.12	195.15 ± 45.12	a,c

a ; significantly different between pre-treatment and the second week($p<0.05$)

b ; significantly different between the second week and the fourth week($p<0.05$)

c ; significantly different between pre-treatment and the fourth week($p<0.05$)

* ; sternocleidomastoid muscle

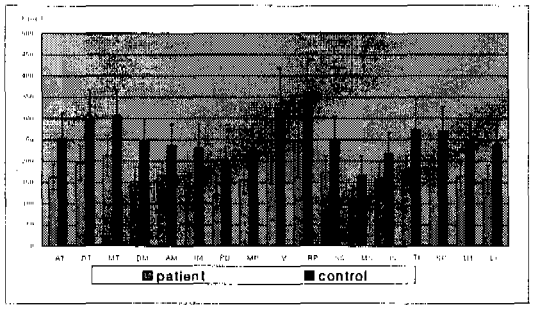

Fig. 6 Pressure pain threshold of the patient group and the control group at pre-treatment

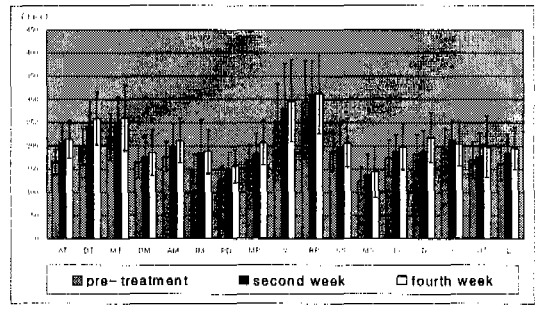

Fig. 7. Pressure pain threshold of the LLLT-patient group at pre-treatment, the second week and the fourth week of laser irradiation

Table 3. Pressure pain threshold of the sham LLLT-patient group at pre-treatment, the second week and the fourth week of sham laser irradiation(Kpa)

	pre-treatment	second week	fourth week	p-value
anterior temporalis(AT)	155.81 ± 33.89	181.61 ± 33.38	197.89 ± 33.83	a,b,c
deep temporalis(DT)	192.11 ± 42.90	210.67 ± 44.16	213.29 ± 44.99	a,c
middle temporalis(MT)	201.93 ± 43.27	218.88 ± 34.50	224.75 ± 45.67	c
deep masseter(DM)	133.96 ± 22.52	141.89 ± 34.45	148.99 ± 26.53	c
anterior masseter(AM)	151.31 ± 29.19	159.53 ± 32.67	166.78 ± 28.02	c
inferior masster(IM)	133.66 ± 19.43	143.26 ± 25.64	162.13 ± 36.12	b,c
posterior digastric(PD)	110.74 ± 19.68	117.30 ± 25.09	124.35 ± 18.40	
medial pterygoid(MP)	136.94 ± 24.24	152.71 ± 29.19	167.75 ± 35.33	a,b,c
vertex(V)	178.46 ± 42.33	216.96 ± 33.80	204.89 ± 43.96	a
reference point(RP)	187.00 ± 20.76	199.28 ± 50.16	193.99 ± 40.32	
superior SCM*(SS)	151.58 ± 22.87	148.46 ± 27.63	165.71 ± 27.94	b,c
middle SCM*(MS)	97.40 ± 14.49	96.47 ± 24.40	106.21 ± 22.05	
inferior SCM*(IS)	136.53 ± 32.97	135.49 ± 47.48	161.93 ± 48.70	c
trapezius insertion(TI)	169.28 ± 23.80	156.16 ± 25.20	187.36 ± 43.63	b
splenius capitis(SC)	168.51 ± 31.66	182.70 ± 24.32	165.56 ± 30.36	a
upper trapezius(UT)	154.54 ± 21.50	160.36 ± 27.84	164.96 ± 32.55	
lateral capsule(LC)	148.69 ± 26.05	158.94 ± 30.42	171.21 ± 28.79	c

a ; significantly different between pre-treatment and the second week($p<0.05$)

b ; significantly different between the second week and the fourth week($p<0.05$)

c ; significantly different between pre-treatment and the fourth week($p<0.05$)

* ; sternocleidomastoid muscle

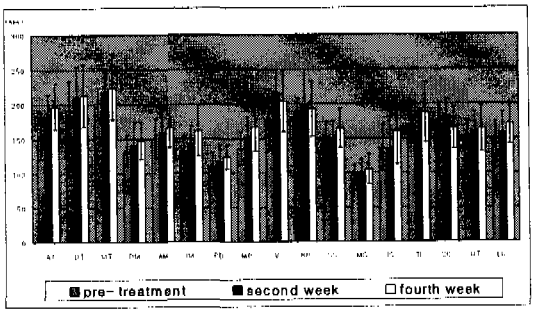

Fig. 8. Pressure pain threshold of the sham LLLT -patient group at pre-treatment, the second week and the fourth week of sham laser irradiation

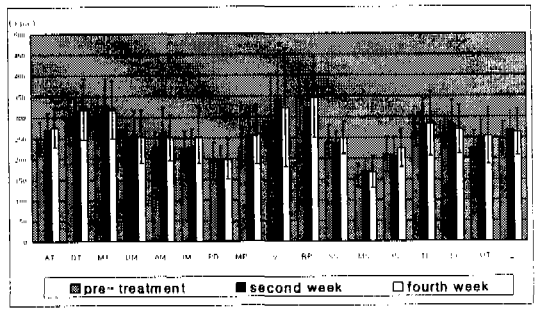

Fig. 9. Pressure pain threshold of the LLLT-control group at pre-treatment, the second week and the fourth week of laser irradiation

Table 4. Pressure pain threshold of the LLLT-control group at pre-treatment, the second week and the fourth week of laser irradiation(Kpa)

	pre-treatment	second week	fourth week	p-value
anterior temporalis(AT)	249.00 ± 41.14	271.50 ± 40.45	276.76 ± 48.38	a,c
deep temporalis(DT)	297.42 ± 62.58	310.32 ± 51.82	318.92 ± 75.93	
middle temporalis(MT)	308.61 ± 42.99	327.74 ± 64.96	317.55 ± 68.70	
deep masseter(DM)	245.93 ± 37.19	258.25 ± 57.32	253.37 ± 63.91	
anterior masseter(AM)	227.84 ± 36.68	262.60 ± 59.73	251.04 ± 55.15	a,c
inferior masster(IM)	223.63 ± 42.00	228.82 ± 42.84	251.85 ± 63.84	b,c
posterior digastric(PD)	195.15 ± 44.26	199.39 ± 32.99	198.18 ± 46.89	
medial pterygoid(MP)	228.97 ± 46.93	257.58 ± 64.17	257.50 ± 71.06	a
vertex(V)	305.55 ± 99.12	342.19 ± 110.98	321.53 ± 141.48	
reference point(RP)	346.91 ± 80.12	321.87 ± 58.91	347.23 ± 96.30	
superior SCM*(SS)	239.81 ± 41.25	237.61 ± 25.86	249.60 ± 38.23	
middle SCM*(MS)	158.78 ± 28.75	168.50 ± 31.46	168.21 ± 39.37	
inferior SCM*(IS)	209.70 ± 42.05	206.84 ± 45.12	226.20 ± 45.95	b
trapezius insertion(TI)	263.80 ± 33.98	279.46 ± 64.81	284.76 ± 77.46	
splenius capitis(SC)	262.54 ± 37.47	281.25 ± 57.84	270.30 ± 59.30	
upper trapezius(UT)	224.74 ± 42.25	245.01 ± 45.85	254.69 ± 67.99	a,c
lateral capsule(LC)	247.34 ± 39.98	268.10 ± 45.33	263.12 ± 54.97	a

a ; significantly different between pre-treatment and the second week($p<0.05$)
b ; significantly different between the second week and the fourth week($p<0.05$)
c ; significantly different between pre-treatment and the fourth week($p<0.05$)
* ; sternocleidomastoid muscle

the treatment. The increased PPT differences of the LLLT-patient group were significantly increased in anterior masseter, inferior masseter and posterior digastric muscle at second week of laser irradiation, and middle temporalis, anterior masseter and posterior digastric muscle at fourth week of laser irradiation in the comparison of those in the sham LLLT-patient group($p<0.05$). In the other muscles, the increased PPT differences do not differ between the actual LLLT-patient and the sham LLLT-patient group.

Table 7 shows the distribution of muscles which exhibited the significant PPT differences according to the treatment period in the LLLT-patient and the sham LLLT-patient group. In the LLLT-patient group, the PPT value at the second week of laser irradiation were significantly higher than those at pre-treatment in the facial muscles such as anterior temporalis, middle temporalis, posterior temporalis, anterior masseter, inferior masseter, posterior digastric and medial pterygoid and lateral capsule, and those at the fourth week

Table 5. Pressure pain threshold of the sham LLLT-control group at pre-treatment, the second week and the fourth week of sham laser irradiation(Kpa)

	pre-treatment	second week	fourth week	p-value
anterior temporalis(AT)	257.24 ± 65.74	274.98 ± 71.53	284.82 ± 65.65	c
deep temporalis(DT)	295.95 ± 74.14	317.06 ± 91.89	327.29 ± 80.32	c
middle temporalis(MT)	304.59 ± 71.55	325.46 ± 70.82	334.49 ± 72.49	a,c
deep masseter(DM)	244.70 ± 62.05	256.49 ± 72.84	255.87 ± 54.21	
anterior masseter(AM)	240.02 ± 59.79	248.42 ± 59.36	260.79 ± 60.19	
inferior masster(IM)	234.28 ± 64.48	246.32 ± 71.33	247.78 ± 61.31	
posterior digastric(PD)	191.90 ± 37.07	194.20 ± 39.02	203.87 ± 36.11	c
medial pterygoid(MP)	224.95 ± 65.75	246.88 ± 74.14	252.51 ± 52.50	c
vertex(V)	327.54 ± 101.19	361.80 ± 134.33	389.68 ± 154.30	c
reference point(RP)	367.75 ± 100.09	360.54 ± 109.82	359.16 ± 123.31	
superior SCM*(SS)	248.94 ± 68.86	256.04 ± 58.61	264.38 ± 66.52	
middle SCM*(MS)	170.59 ± 56.22	172.31 ± 47.92	177.41 ± 52.89	
inferior SCM*(IS)	221.16 ± 56.96	226.91 ± 61.15	231.12 ± 53.60	
trapezius insertion(TI)	276.30 ± 95.99	291.00 ± 99.67	305.03 ± 104.99	c
splenius capitis(SC)	275.26 ± 68.05	295.11 ± 70.72	284.02 ± 74.08	a
upper trapezius(UT)	254.84 ± 78.58	249.15 ± 59.05	264.53 ± 62.55	
lateral capsule(LC)	231.27 ± 64.79	245.44 ± 62.96	266.88 ± 71.79	c

a ; significantly different between pre-treatment and the second week($p<0.05$)
b ; significantly different between the second week and the fourth week($p<0.05$)
c ; significantly different between pre-treatment and the fourth week($p<0.05$)
* ; sternocleidomastoid muscle

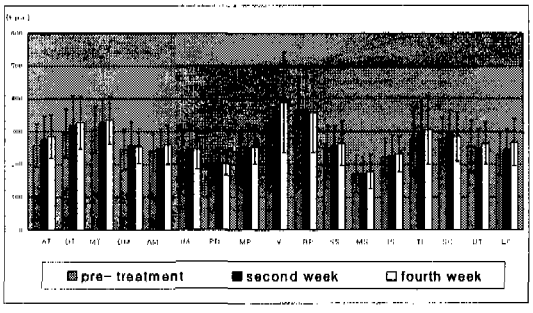

Fig. 10. Pressure pain threshold of the sham LLLT-control group at pre-treatment, the second week and the fourth week of sham laser irradiation

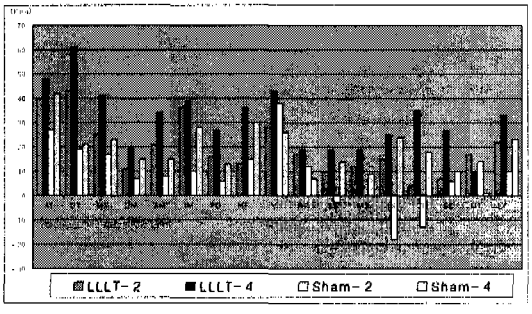

Fig. 11. Comparison of the increased pressure pain threshold differences in the LLLT-patient and the sham LLLT-patient group

Table 6. Comparison of the increased pressure pain threshold differences in the LLLT-patient and the sham LLLT-patient group(Kpa)

	Difference between the second week and pre-treatment			Difference between the fourth week and pre-treatment		
	LLLT patient group	sham LLLT patient group	p-value	LLLT patient group	sham LLLT patient group	p-value
anterior temporalis	39.65±93.08	26.80±17.12	0.1915	48.28±46.76	42.09±20.68	0.3401
deep temporalis	42.92±41.72	18.56±34.46	0.1718	60.89±53.27	21.18±17.00	0.0453
middle temporalis	25.42±44.72	16.96±39.14	0.2080	41.20±65.31	22.83±36.70	0.1098
deep masseter	11.28±29.51	7.93±24.63	0.0677	20.07±42.37	15.04±23.62	0.0364
anterior masseter	21.44±33.69	8.22±24.94	0.0279	34.04±41.51	15.47±17.11	0.0101
inferior masster	35.60±64.11	9.61±22.09	0.0302	38.61±31.96	28.48±24.61	0.1455
posterior digastric	16.13±27.94	6.56±20.49	0.0211	27.20±31.08	13.61±20.57	0.0096
medial pterygoid	13.30±29.58	15.77±21.04	0.1131	36.47±38.51	30.81±29.82	0.0320
vertex	27.87±77.49	38.50±23.07	0.2078	43.47±80.77	26.43±35.56	0.1136
reference point	17.40±50.46	12.28±48.44	0.0053	19.27±72.34	6.99±36.66	0.0119
superior SCM*	9.97±33.33	-3.12±23.68	0.0016	19.00±56.84	14.13±16.68	0.0190
middle SCM*	11.58±28.30	-0.93±19.40	0.0029	18.90±41.18	8.81±17.29	0.0143
inferior SCM*	14.78±33.60	-17.97±65.79	0.0024	24.55±52.18	25.40±27.89	0.0305
trapezius insertion	4.07±44.95	-13.11±28.16	0.1780	35.11±40.11	18.08±41.26	0.2290
splenius capitis	7.19±37.39	5.82±28.22	0.1378	27.35±43.14	10.43±28.03	0.0778
upper trapezius	16.99±34.91	14.19±22.05	0.2955	10.74±47.80	1.05±28.91	0.1053
lateral TMJ	21.89±33.53	10.25±36.10	0.1139	32.57±48.75	22.53±24.12	0.1923

* ; sternocleidomastoid muscle

Table 7. Distribution of muscles which exhibited the significantly increased PPT values according to the treatment period in the LLLT-patient and the sham LLLT-patient group(p<0.05)

	second week	fourth week
LLLT-patient group	anterior temporalis, middle temporalis, posterior temporalis, anterior masster, inferior masseter, digastric posterior, medial pterygoid, lateral capsule	deep masseter, middle SCM*, inferior SCM*, trapezius insertion, upper trapezius, splenius capitis
Sham LLLT-patient group	anterior temporalis, middle temporalis, medial pterygoid	posterior temporalis, anterior masseter, deep masseter, inferior masseter, superior SCM*, inferior SCM*, lateral capsule

* ; sternocleidomastoid muscle

Table 8. Craniomandibular index and pain intensity of all group at pre-treatment, the second week and the fourth week.

		pre-treatment	second week	fourth week	p-value
LLLT-patient group	PI	0.75 ± 0.26	0.53 ± 0.27	0.29 ± 0.19	a,b,c
	DI	0.16 ± 0.14	0.15 ± 0.13	0.13 ± 0.13	
	CMI	0.46 ± 0.16	0.34 ± 0.18	0.21 ± 0.14	a,b,c
	Pain*	2.55 ± 1.66	2.00 ± 2.05	1.45 ± 1.57	c
Sham LLLT-patient group	PI	0.82 ± 0.35	0.60 ± 0.16	0.48 ± 0.26	c
	DI	0.18 ± 0.15	0.15 ± 0.09	0.14 ± 0.10	
	CMI	0.50 ± 0.07	0.37 ± 0.06	0.31 ± 0.04	
	Pain*	2.31 ± 1.54	1.88 ± 1.64	1.56 ± 1.18	
LLLT-control group	PI	0.21 ± 0.24	0.16 ± 0.16	0.05 ± 0.09	b,c
	DI	0.05 ± 0.13	0.03 ± 0.04	0.04 ± 0.06	
	CMI	0.12 ± 0.13	0.09 ± 0.09	0.05 ± 0.05	c
	Pain*	0	0	0	
Sham LLLT-control group	PI	0.11 ± 0.13	0.08 ± 0.10	0.06 ± 0.10	
	DI	0.09 ± 0.08	0.08 ± 0.06	0.06 ± 0.05	
	CMI	0.10 ± 0.19	0.08 ± 0.10	0.06 ± 0.16	
	Pain*	0	0	0	

a ; significantly different between pre-treatment and the second week($p<0.05$)

b ; significantly different between the second week and the fourth week($p<0.05$)

c ; significantly different between pre-treatment and the fourth week($p<0.05$)

PI ; palpation index

DI ; dysfunction index

CMI ; craniomandibular index

* ; Pain intensity was evaluated with numerical analogue scale(NAS)

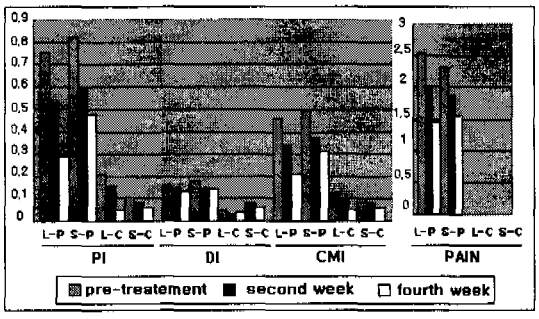

Fig.12. Craniomandibular index and pain intensity of all group at pre-treatment, the second week and the fourth week.

were significantly higher than those at pre-treatment in neck muscles such as deep masseter, middle sternocleidomastoid, inferior sternocleidomastoid, trapezius insertion, splenius capitis and upper trapezius($p<0.05$). In the sham LLLT-patient group, the PPT values at the second week of sham laser irradiation were significantly higher than those at pre-treatment in anterior temporalis, middle temporalis and medial pterygoid, and those at fourth week were significantly higher than those at pre-treatment

in posterior temporalis, anterior masster, deep masseter, inferior masseter, superior sterno-cleidomastoid, inferior sternocleidomastoid, lateral capsule($p<0.05$).

Table 8 and figure 12 shows craniomandibular index and pain intensity(NAS) of all group at pre-treatment, the second week and the fourth week of irradiation. Palpation index(PI) were significantly decreased at the second and fourth week of laser irradiation in the LLLT-patient group, at the fourth week in the sham LLLT-patient group and at the second and fourth week in the LLLT-control group($p<0.05$), but not decreased in the sham LLLT-control group. Dysfunction index(DI) was not decreased in any group. Although craniomandibular index was significantly decreased at the second and the fourth week in the LLLT-patient group and at the fourth week in the LLLT-control group($p<0.05$), it was not decreased in the sham-patient and the sham-control group. Numerical analogue scales were decreased only at the fourth week. In the sham LLLT-patient, only palpation index was significantly decreased at fourth week. Pain intensity was significantly decreased only at fourth week in the LLLT-patient group.

Ⅳ. DISCUSSION

Temporomandibular disorders(TMD) involves the masticatory musculature, the temporomandibular joint and associated structure, or both[39]. The beginning of TMD usually occurs with muscular imbalance and joint disorders generally go company with muscular disorders. Okeson[2] suggested that muscle disorders and joint disorders could influence each other. Even in internal derangement, Isberg et al[40] demonstrated an increased muscle activity in elevator muscles. Thus, it can be assumed that the objective evidence of muscle involvement, e.g. algometry, is able to be used in assessment and therapy evaluation of TMD.

The algometer which measures PPT, quantification of muscle tenderness, has been reported to be useful clinically in muscle tenderness evaluation[24-26,41,42]. When the algometer began using at first in 1930, it's disadvantage was to be insufficient of precision because it worked on spring load principle. After then, Fischer[41] and Tunks et al[27] developed the algometer of improved design working by means of mechanical force and Jensen et al[31] and Brennum et al[42] introduced electronic algometer. Because such the electronic algometer is made of strain gauge principle, more precise measurement can be made than previously developed machine, and it can be applied easily to clinical practice and obtain the constant results from the repetitive measurements. Many researchers reported about the validity and reliability of PPT measurement using algometer[28,24 26,41]. Fischer[41] suggested that PPT measurement was excellent in reproducibility and validity. Chung et al[25] reported that there was high intraexaminer and interexaminer reliability in a study on PPT measurement of head and neck muscles of 40 normal subjects, and concluded that the algometer can be very useful to investigate the head and neck muscles tenderness for clinical practice and research.

When the algometer is used, it is important to standardize all variables of application site, application method and application rate to reduce the measurement errors and obtain the reliable results. The electronic algometer used in this study is designed to control easily the application rate while may be the main cause of error. List et al[43], Fischer[41] and Tunks et al[27] did not mention concretely about application rate and proposed that it should depend on the

experience of investigators. In this study, the application rate used was 30Kpa/sec recommended by manufacturer[36]. Even if no matter have been made clear about the most appropriate application rate, it should be fast enough to avoid damage from prolonged pressure to the tissue and measurement error owing to the investigator's fatigue from maintaining of slow rate, and slow enough to allow the investigator to apply pressure with constant rate for sufficient time so that the true PPT should not be overestimated due to reaction time of each patient[10]. Furthermore, List et al[28] and Doland and Keffem[44] emphasized that a constant pressure rate is necessary to obtain a good reliability with the algometer. As Olavie et al[12] evaluating IR laser effect at treated and non-treated trigger points by algometer did not mention the application rate, their data failed to be compared with the present data.

Many researchers[10,15,16,18] used visual analogue scale(VAS) in evaluation of LLLT effect and reported that it was significantly decreased with laser irradiation. It may be attributable to the subjectivity of individual perception. Snyder-Mackler et al[13] reported that VAS may not be the ideal tool to assess trends of predictability across subjects. Palpation index was also used to evaluate the treatment effect in myofascial patients. Fricton et al[20] reported that palpation index of myofascial patient was decreased after treatment. Because the examiner's fingers are used in palpation and so its reproductivity is always not good, it is difficult to say that palpation index is objective thoroughly. Another criteria used in evaluation of laser effect were 5-hydrxyindoleacetic acid[45], skin resistance[46] and the distal sensory latency[47]. Since the early 1980's, laser researches have improved[45-50]. Investigators have discussed the nonthermal effects of He-Ne laser irradiation. Walker[45] reported success with the laser in relief of chronic pain. The relief of pain was accompanied by increase in the urinary excretion of 5-hydroxyindoleacetic acid, a by-product of serotonin. Subsequently, she concluded that laser irradiation may have an effect on serotonin metabolism, thereby serving as a mechanism of pain relief. Snyder-Mackler et al[13] found that three short-duration He-Ne laser treatment normalized skin resistance in patient with musculoskeletal trigger points. Most recently, a double-blind study by Snyder-Mackler and Bork[50] determined that He-Ne laser treatment increased the distal sensory latency (corresponding to a decrease in sensory nerve conduction velocity) of superficial radial nerve in humans. They hypothesized that this increase in sensory latency could be a mechanism for pain relief, and thus the He-Ne laser may be beneficial analgesic modality.

This finding that PPT in TMD patients was significantly lower than one in control subjects was fully in accord with other study[51] that had examined PPT by algometer. In the study of Chung et al[25], there was no side-to-side differences in pre-treatment group. It suggested that patient actually demonstrated a diffuse lowering of pain threshold. In tension headache and myofascial pain-dysfunction syndrome/ fibromyalgia patients, it has been suggested that diffuse disruption of central modulating system may play a pivotal pathophysiology in TMD[27]. It explains that PPT values of patient group were lower all over than those of control group in this study. Based on the studies mentioned above, adding left and right PPT values was used in this study.

Trigger points are significant, albeit controversial, factor in musculoskeletal researches. Snyder-Mackler et al.[13] found both a statistically significant reduction of pain and

increased skin resistance at the trigger points. Olavie et al[12] suggested that IR 904nm laser treatment might have a beneficial effect on the pain threshold when it is low, as is usually the case in the trigger points during myofascial pain syndromes and concluded that low power infrared laser had a beneficial effect on PPT in sensitive trigger points and also a minor effect in the contralateral side. On the other hand, the same laser therapy had no effect on the pain threshold in normal subjects[52,53] and on normal pain threshold[54]. Based on the result of above studies, it was understood that the PPT values of some muscles in the LLLT-normal control group were not increased but PPT values of the other muscles were increased because the normal subjects might have sensitive tender points. Thus, it is considered that only trigger points in myofascial pain syndrome have to receive the laser irradiation.

One analysis by Klein and Eek[11] showed that no statistically differences were not found between LLLT and placebo group in any of the pain, ability, or range of motion parameters measured. Waylonis et al[14] reported no statistical difference between LLLT and placebo group in chronic myofascial pain. However, Ceccherelli et al[16] reported positively in cervical myofascial pain coincident with the results of this study. On general, the increased PPT differences by laser irradiation of LLLT-patient group were clinically greater than those of sham LLLT-patient group and several muscles have significant differences between the LLLT-patient and the sham LLLT-patient group. Definite consequence can not be made from this results but actual laser-induced effect might be slightly superior to placebo.

In conclusion of two meta-analysis[17,55], LLLT effect is still controversial as the result of this study. Although Thorsen et al[55] concluded in meta-analysis of 40 trials that LLLT had no effect on musculoskeletal pain, Beckerman et al[17] assessed the results of 36 trials and suggested that the efficacy of laser therapy for musculoskeltal disorders seemed, on average, to be larger than the efficacy of a placebo treatment. In this study, actual laser-induced treatment group was slightly superior to placebo and a possible placebo effect could not be completely ruled out. The data of this study and results of previous mentioned study demonstrate that low power laser may be an effective adjunct to conventional physical therapy.

The GaAlAs laser is known to penetrate to depths of 1cm to 5cm in soft tissue. This depth of penetration should be adequate to treat the major muscle full thickness in facial and neck muscle in TMD patient. Because treatment period of effective pain reduction is thought to be associated with tissue thickness and thickness of neck muscles is known to be thicker than that of facial muscles, effective treatment period in facial muscles is shown to be shorter than neck muscles. This study recommended 2 weeks for LLLT of trigger points in facial muscles. In fact, even though the counter force is usually utilized to measure true PPT of that muscle, the fact that surrounding tissues are included in measuring of PPT in that muscle may be considered especially in neck muscle which have large amount of soft tissue. Thus, such the consequence might be effected from thick tissue needed of longer irradiation period and more doses, and difficult PPT measurement procedure due to surrounding tissues.

The improvement of palpation index(PI) after laser irradiation is agreed with increase of PPT in patient groups. PI results of LLLT-patient group were very superior to sham LLLT-patient group. PI of LLLT-control group was reduced contrary to result of PPT . Even if PI is seemed

to be a good criteria for treatment effectiveness considering results of only palpation index excluding of PPT, PI is not good criteria in view of the results of Olavie et al[12]. DI(dysfunction index) was not reduced with laser irradiation in this study. Bezuur et al[9] also found that infrared laser irradiation of myogenous patients had not increased significantly the maximum mouth opening. Based on above studies, LLLT may not improve dysfunction of TMD. CMI(cranio-mandibular index) was significantly decreased in LLLT group because of influence of PI.

O'Brian[56] reported that patient with a chronic fluctuating disease would be expected to enter a trial in bad period and thus, to improve independent of therapy. McNeil[39] suggested that mandibular dysfunction and pain may take a cyclical course and the constancy of clinical signs is low. As small sample size and fluctuating nature of chronicity interact complicatedly, a part of actual laser-induced effect may have been concealed. Several researchers[57,58] concluded that the therapeutic effectiveness in trials without a control group was questionable. But as emphasized by Okeson et al.[59] it is extremely difficult to establish a realistic control sample for placebo studies clinically because there are ethical considerations about no treatment for a long time, and these control group patients, in longitudinal study, who receive no treatment will remain symptomatic and will soon drop out of the group and seek treatment elsewhere. Further studies for evaluation of this problem are needed.

Although some of them had a symptom in need of treatment to want to be treated, another part of them had mild symptom not to feel the need of treatment and if author had not made them patient group, they might not have received the treatment. As symptoms of subjects were manifested in NAS, mean value of NAS in the LLLT-patient group at pre-treatment was low as 2.55 ± 1.66 and that in the sham LLLT-patient is 2.31 ± 1.54 for patient. Thus, the actual laser-induced effect might be concealed.

Early clinical works of laser therapy was usually anecdotal, unblinded, poorly controlled, and incompletely reported. Standardization has improved markedly over the last decade. This study remains more variable than might be desired, but it is almost uniformly better designed, better controlled, and more carefully blinded.

Other intervening variables such as time of a day, activity level, duration of chronicity, sexual differences and stress level were not controlled for and subsequently may have influenced these data. Therefore, further studies where problems will be corrected and better criteria will be used are still needed.

V. CONCLUSIONS

To evaluate the effect of low level laser therapy in the head and neck muscles of the TMD patient and normal control group respectively according to actual and placebo treatment and the effective treatment period of LLLT in TMD patient, 19 dental students with TMD and 20 without TMD, at Pusan National University, were investigated with the following findings ; pressure pain threshold(PPT) on 32 musculoskeletal palpation point, craniomandibular index(CMI) as a clinical findings, and degree of pain intensity as a subjective symptoms at pre-treatment, the second week and the fourth week of laser or sham laser irradiation.

The obtained results were as follows:

1. The PPT values of patient groups were significantly lower than those of control group

at pre-treatment($p<0.05$).

2. The PPT values of patient group were significantly increased($p<0.05$), and the increased PPT differences of LLLT-patient group were greater than those of sham LLLT-patient group.
3. The PPT values after laser irradiation were not increased in LLLT-control and sham LLLT-control group.
4. In LLLT-patient group, the PPT values in the facial muscles were significantly increased from the second week of laser irradiation than those at pre-treatment and those in neck muscles were significantly increased from the fourth week of laser irradiation than those at pre-treatment($p<0.05$)
5. In LLLT-patient group, pain intensity and CMI were significantly decreased with laser irradiation($p<0.05$).

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국문초록

저출력레이저 조사가 측두하악장애환자의 압력통각역치에 미치는 영향

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측두하악장애환자와 정상대조군의 두경부 근육에 있어서 실제 또는 위약 치료에 따른 저출력 레이저의 효과와 측두하악장애환자에서 저출력 레이저의 효과적인 치료기간을 평가하기 위하여, 측두하악장애를 가진 부산대학교 치과대학생 19명과 측두하악장애의 병력이나 증상이 없는 부산대학교 치과대학생 20명을 대상으로 치료전, 치료 2주 및 치료 4주에 구외촉진이 가능한 32 근골격 촉진점의 압력통각역치와 각각의 동통정도와 두개하악지수를 측정하여 다음과 같은 결론을 얻었다.

1. 치료전 환자군의 압력통각역치는 정상대조군 압력통각역치보다 낮았다($p<0.05$).
2. 환자군의 압력통각역치는 유의하게 증가하였으며($p<0.05$) 레이저 조사-환자군의 증가된 압력통각역치는 레이저 모의조사-환자군의 증가된 압력통각역치보다 더 크게 나타났다.
3. 대조군에서는 레이저 조사나 모의 조사에 의해 압력통각역치의 변화가 없었다.
4. 레이저 조사-환자군의 압력통각역치가 안면근육에서는 치료2주부터 유의하게 증가하였고 경부근육에서는 치료4주부터 유의하게 증가하였다($p<0.05$)
5. 레이저 조사-환자군에서 동통의 정도와 두개하악지수는 유의하게 감소하였다($p<0.05$).